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A POWER OF TOWN SIZE PREDICTS AN INTERNAL INTERACTING*

A CONTROLLED EXPERIMENT RELATING THE AMOUNT OF AN INTERACTION TO THE NUMBER OF POTENTIAL INTERACTORS

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THE DIMENSIONAL MODEL HYPOTHESIZED

THE research reported here sought an answer to the question: How may the amount of a mass interaction in a community depend on its size?

It is commonly said that there is more interaction for the average person in cities than in villages. Life in the city is said to be more exciting, to move faster, to be more varied. Life in smaller communities is thought to have fewer interperson stimulations and respondings (whatever their satisfying quality). In small communities one is likely to speak with, deal with, see, hear about, or otherwise attend to fewer persons per day, whether directly or by symbolic mediation, than does the average metropolitan. Can such common-sense generalizations be exactly formulated and measured and used as predictive rules under specified and observable preconditions? Will some dimensional formula describe the general curve relating the quantity of any interacting to the size of the given population? Then if other factors are constant, can the volume of interacting in specified ways be predicted statistically as a function of the number of interactors?

If these questions can be answered affirmatively by experiments, as we believe they can be, a further basic question for sociologists emerges. We ask whether from indices measuring the amounts of specified kinds of interaction between people estimates could be derived for the total amount of interacting of all kinds in a community.[1]

Could the total volume of social behavior in communities become measurable at least relatively between communities? For we believe from our interactance formula (3)† or principle of demographic gravitation and from our more inclusive transact model (5) that the total quantity of interaction among persons in communities should be estimable. These estimates should improve according as researchers could measure the number of representative interacts and the number of interactors while holding constant the context of the transact, i.e., controlling the factors of time, space, values, and other standardizable circumstances.

An opportunity to begin answering such questions was given to the Washington Public Opinion Laboratory by Project Revere. This was a contract research from the Air Force to develop principles for airborne leaflet operations. Such leaflet operations provided an almost ideal laboratory for controlled experiments testing mathematical models for interaction. The form of communicative interaction tested was the all-or-none spreading of a message on a leaflet among a population. This message diffusion was measured by the percentage of the population knowing that the leaflet requested each finder to pass one on and to mail back a stub. The public's fuller response, called "compliance," was observed here by the number of leaflet stubs (postage-free tracer postcards) which were either passed on to someone else or torn off a leaflet, filled out, and mailed back to the Laboratory. The stimulation of the public to interact thus with each other and with the research role-actors was well under the researcher's control. The public's response was easily measured, clearly identified as due to our stimulation and only to that, and in cleanly controllable context.

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[1] This is a bit like expecting a general price level to be determined from observed prices of representative commodities, each commodity price in turn being an average of many selling-and-buying interacts.

† This and following numbers in parentheses relate to the author's references appended to this article.

As trial answers, or hypotheses, about the basic question of the dependence of interacting upon the number of interactors, we chose on the basis of incompletely controlled pretests (4) a "power of the population" as a simple model to test. (See Equation 1 and 2.) This is a dimensional family of curves which say that the amount of some homogeneous kind of interacting between people is expected to be proportional to some power of the number of people (when, as usual, the context is either held constant at specified levels or varies without correlation to that interacting).

This hypothesis is expressible in general as:

$$\left[B_0 \overset{\text{hyp.}}{=} P^p\right] \qquad \text{(Eq. 1)}$$

the dimensional formula for full self-interaction p times within a population, P, or in more detail, specific to the local situation, as:

$$B_0 \overset{\text{hyp.}}{=} aP^p + b \qquad \text{(Eq. 2)}$$

the statistical formula for the same internal interaction.

As always, the dimensional formula denoted by square brackets specifying the exponent parameter only states the *shape* of curve or most generalized aspect of the relation between the independent and dependent variables, whereas the statistical formula also states the local accident of the *slope* and *location* of the curve by specifying its coefficient parameter, a, fixing the units, and by specifying its addend parameter, b, fixing the origin point.

When this exponent, p, is negative, the formula is called a generalized hyperbola (if in continuous form), or a generalized harmonic series (if in discrete data). The harmonic series are the inverse natural numbers, 1/1, 1/2, 1/3, 1/4 ··· 1/N, and these are "generalized" when the exponent is other than unity.

This power of a population model has two variables with two forms for the dependent variable. The independent variable, which was varied in controlled amounts by the researcher, was the population, P, of the community. Thus we chose six communities, as shown in Table 1, varying in size in a roughly geometric series from around a thousand population to over three-hundred thousand. The dependent variable was the public's reaction to the leaflets in either (a) picking one up off the ground, filling it out, and mailing it in, or (b) passing one on to someone else to mail in. The former was called physical diffusion, and the latter was called social diffusion. Both behaviors involved interaction between the research role-actors and the reactors who mailed leaflets back as requested. But the social diffusion involved further interaction among givers and receivers of leaflets.

TABLE 1. DIFFUSION AND POPULATION IN SIX TOWNS

Town	Population	Diffusion ("social and physical") (= % pop. mailing back)	
		Expected	Observed
Poulsbo	1,304	13.1	10.3
Okanogan	2,013	9.58	7.3
Raymond	4,150	6.24	6.1
Ellensburg	8,430	4.65	4.0
Everett	34,600	3.48	3.9
Birmingham	325,994	3.14	3.1

$r_{eo} = .99$; $p(\chi^2) > .05$.

In relating both physical and social diffusion to the context factor of population size by this model, at least one social precondition is hypothesized, i.e., taken as a mathematical assumption in deriving the formula, Equation 2, which states the model exactly. The model assumes *equal opportunities* for all persons. Equal *opportunities* mean that in respect to this act everyone had an equal probability of getting a leaflet. It implies that the population was not composed of sub-populations which might have very unequal likelihood of getting at least one leaflet per person.

In summary, the model here, Equation 2, expresses in mathematical language of a dependent variable equated to a power of an independent variable the following social hypothesis: *The transact of diffusing any message (or any other form of one-way, all-or-none interacting) is expected to vary with the size of the population when weighted by the exponent (which may measure the proportion of actual interactors in that population of potential interactors), provided that the other factors of a transact are either constant or uncorrelated with the diffusing.* This is our "population power" hypothesis of interaction stating in prose what Equation 2 states in algebraic symbols. It implies that insofar as these operationally defined and culture-transcending variables are related to each other, fully and solely, by the two preconditions hypothesized, in just so far the results specified by Equation 2 can be expected to recur always and everywhere.

THE EXPERIMENT TESTING THE MODEL

A testing of this population-power model was made in Project Revere somewhat as a by-product of other tests. Six communities were found, as exhibited in Table 1, which had received airborne drops of our standard leaflets and whose sizes represented roughly the following six points on a power scale: 10^3 (2^0, 2^1, 2^2, 2^3, —, 2^5, —, —, $2^{8.5}$). With the population factor thus varying, the amount of each community's response by physical and by social diffusion was measured by the percentage of the population in each town mailing back one leaflet which the mailer had either picked up or received from someone else.

A plane spread the dramatized leaflet calling on each citizen to be a modern Paul Revere and help spread a trial message such as could save lives in a bombing emergency. The leaflets were scattered over each town's area at a ratio of one leaflet per capita, from about five hundred feet altitude. The timing was on a Wednesday noon in good weather. Every inhabitant who went outdoors or lived in a household where some other normal member went outdoors had about an equal physical opportunity of finding a leaflet near his doorstep or of having one brought to him.

Toward control of the six factors of a transact other than the population size, the following approximations to constancy or controlled variation from town to town can be recorded:

The Acts factor. The kind of interacts in getting, giving, and sending postcards back were the same for every town. The diffusing of the message was solely from leaflets and interperson contacts as all information about the leaflets by radio, newspaper, and wire services had been effectively sealed off in those communities during the 69 hours of the experiment.

The Time factor. The time of day and day of week for the leaflet drop and the 69-hour interval to Saturday morning for mailbacks to be received were the same for all six towns.

The Space factor. The distance from people to available leaflets varied negligibly and randomly over a few yards from their doorsteps in every town. The density of people per unit area increased with town size, but this effect of space on the leaflet interacting, if any, would be correlated with and reflected in the dependence of the interacting upon town size—which is the variable at issue. (The reader should note that in expecting interacting to vary as a function of the population size no implication is intended that this is purely due to more bodies being present. The number of people is simply an index of whatever varies with that number of people—their interests and habits, their knowledge and possessions or anything else the amount of which is measurable in whole communities by counting heads.)

The Values factor. The value systems or motivations appealed to by the "Paul Revere" leaflet message and civil defense implications were common to the United States in 1953 and probably fairly much the same from town to town however much individuals varied in response to that appeal.

The Residual factors. These were uncontrolled and left to chance to average up somewhat alike from town to town. We avoided choosing any towns with unusual features unrelated to their size. From our other studies including analyses of 14 demographic and ecological indices the only variable we found which might disturb the comparability of the six towns was the Negro-white difference in Birmingham. Negroes mailed back less than whites, so Birmingham's mailbacks were slightly less than they would have been if it were an all-white town like the other five. This bias was too small, however, to alter the fit of the model in Figure 1 by much more than one unit in the third decimal place of the correlation coefficient.

The facts observed in this controlled experiment on diffusion by town size are tabulated in Table 1 and graphed in Figure 1. The data are fitted excellently by a "die-away" or negative power curve. *The relative interacting, whether physical or social, varied inversely with a power of the pouplation.*[2] The absolute number of persons diffused or complying increased as town size increased—but increased at a slower and slower rate.

For the total interacting, combining both physical and social diffusion, the population power model fitted the data very closely. The correlation coefficient between the total diffusion data and the model (= B_h or P^p), Equation 1, was .989. The best-fitting exponent was 0.9, the intercept, b, in Equation 2 was Birmingham's diffusion (3.1 percent), and the curve was fitted by anchoring it on the Birmingham end as the most reliable point. The small discrepancies of the observed total diffusing from this model were not statistically significant as $p(\chi^2) > .2$. In short, the hypothesis that this form of interaction among individuals in a town would vary with a negative power of the population or inversely to town size was clearly confirmed in this testing. The model fitted the total interaction data closely and surely under the specified conditions. But, of course, this must be reobserved by other scientists in further tests with more than six points on the curve before the general hypothesis can be considered fully confirmed.

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[2] The physical and social diffusion when plotted separately showed closely parallel curves but with less excellent fit to the model. See Reference 9 for more detailed analysis.

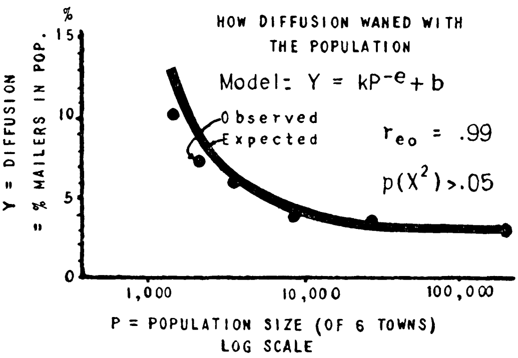

FIGURE 1

INTERPRETATIONS OF THE FINDINGS

What may be the interpretation(s) or explanation(s) of the power relation observed here between town size and message diffusing? What rationale or mechanism may produce it? If its preconditions can be specified and tested in isolation, it should become possible in the future to predict a given town's interaction of some kind from knowledge of its population size and actuarial experience with that kind of interaction.

The precondition we see as most plausible and universal to any culture and period might be called our "relative interstimulation" or "shrinking share" hypothesis.[3] By this explanatory hypothesis we expect that the total interstimulation of all kinds in a town will increase by more than any increase of the population as the town enlarges. The interstimulations mean that the acts of one person constitute a stimulus to which another person responds. The number of possible single interstimulations of one kind between persons, P in number, is proportional to P^2. As suggested by the sociomatrix cross-classifying every person in a row against every person in a column, the maximum number of pair permutations[4] would be P^2 (allowing self-stimulations in the main diagonal cells). But this would be a ceiling since, as towns get larger, it becomes physically impossible for everyone to interact daily with everyone else individually. Therefore, as towns get larger the pair interactions may be expected to be proportional to a power of the population larger than the first power yet smaller than the second power or square. The total pair interactions of all kinds then will vary with the P^{1+q} power of the population where the q in the exponent is less than 1. Then on dividing by the population to get the total per capita pair interacting the expectable formula is P^q (i.e., $P^{1+q}/P^1 = P^q$).

Now the per capita reaction of the population of each town to the leaflet when dropped at a constant ratio of one leaflet per person might be expected within any one culture and period to be constant ($= a$) if they reacted to the leaflets only.

But now consider their reacting to a constant leaflet stimulation in the context of their joint reacting to it and to all the rest of the stimulation of all kinds playing on them and demanding their attention. This relative part that per capita leaflet reacting is of all per capita reacting seems measurable as their ratio. This is the ratio of a constant over a population-to-a-fractional-power. This is a negative fractional power of the town populations (i.e., $a/P^q = aP^{-q} = aP^{p-1}$ in relative terms). Multiplying by the population, P^1, to reexpress this in absolute terms of number of people gives our model, Eq. 2, where $b = 0$. (i.e. $a\,P^{p-1} \cdot P^1 = aP^p$).

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[3] Just as an excellent fit to the hyperbola does not preclude the six-point data from fitting other curves (and requires more discriminating experimental designs to decide), so our offering one behavioral interpretation or explanatory subhypothesis does not preclude other consistent but differently formulated interpretations. Thus Simon's probabilistic formulation for rank-size curves of population might be adapted to provide a more analytic interpretation for our shrinking shares of interstimulations. (See Herbert Simons, "On a Class of Skew Distribution Functions," Biom., 42, Parts 3 and 4 (Dec. 1955).

[4] The number of permutations is here double the number of pair combinations and means that one counts A's initiating an interact with B as a different interact from B's initiating it with A.

This was exactly what was observed. The per capita compliance of mailbacks varied as a negative fractional power of the town's population as shown in the dropping curves in Figure 1. This negative fraction as found by best fitting technics was $-.9$ for the total diffusion (including both physical diffusion and social diffusion) as graphed in Figure 1. *This means that the per capita reacting to the leaflets wanes as the towns enlarge because that reacting becomes a shrinking share of the townsmen's total behavior in any one day.*

This also means that on multiplying by the population, the absolute total reaction of each town to the leaflets varies as a positive fractional power (which is the complement of the negative fraction in the exponent above). In less technical language, it means that as town size enlarges the total absolute leaflet response increases but at a diminishing rate. Of course this translating the per capita leaflet response into the total leaflet response agrees exactly with what was observed since it is but a shift of units. The positive complementary fractional exponent was $+.1$ for total diffusion ($= P^{-.9} \cdot P^{1} = P^{+.1}$).

The hypothesis in this study of compliance in six towns was a very general dimensional one which expected leaflet interacting to vary as some power of the population, and per capita leaflet interacting to vary as a negative fractional power (i.e., as P^{-q}). Beyond this the hypothesis did not specify the size of the exponent nor the size of any other parameters such as the coefficient a or addend b in Equation 2. These were left to be found as the best-fitting parameters in the given data. But as further research narrows the model down, we should learn to what extent these exponents, coefficients, and addends (determining respectively the shape, slope, and location of the curve relative to its coordinates) vary with the particular behavior, or the particular actors, period or place, value system, or other circumstances.

As the exponents converge around some central point in a frequency distribution of best-fitted exponents from many researches, this central exponent may prove a useful index. For it may indicate the relative amount, as between towns, of internal interacting of all kinds. It may eventually become a means of estimating the total interactivity of individuals or tempo of social life in each community. But first many exploratory studies are needed applying constant stimulation to towns of varying size with all else constant to see what exponents relate the interaction tested to the town size.

This shrinking-share mechanism which is proposed to explain the facts is a special case of our "counteractance" model or system of hypotheses (6, 7, 8, 9). This counteractance model attempts a unifying explanation of all cases of generalized hyperbolic curves of behavior, i.e., where the dependent transact varies inversely with some power of one of its factors. The inverse factor is seen as an index of some counteracting or competitive force that resists or cancels out part of the transact at issue. In our present research the compliance or percentage of people mailing a leaflet stub back was the transact or dependent behavior-in-context that was at issue in the series of six towns. The larger the town's population, the more the total amount of competitive interstimulation that is generated. This, we hypothesize, counteracts or reduces the per capita rate of complying responses to the constant leaflet stimulation.

A tenet of dimensional analysis is that the basic dimensions are sufficiently homogeneous (even though manifested in a great diversity of indices) that many confirmed generalizations or laws can be built up in dimensional terms from single representative indices. Thus here from the single particular index of mailing in leaflets we seek to generalize on how the amount of any one kind of interacting depends on the number of interactors, all else being constant. Our hypothesis is not limited to responding to leaflets nor to the situation and culture of the United States during the cold war in 1953. Our hypothesis is deliberately stated in terms general to any all-or-none communicating act that may be done by many people, not more than once each, under conditions approximating equal opportunity, where the varying size of population in a series of towns that are otherwise alike is expected to generate a counteractive effect or competition reducing the per capita act at issue in a hyperbolic curve. This hypothesis can be tested by other investigators in diverse situations using a variety of indices of many kinds of behavior.

For dimensional models seek maximal generality in each of the six major factors of a transact. Thus a dimensional model specifies the form of varying of certain variables and preconditions which are *otherwise* expected to be:

1. General to any *acts* of the form specified regardless of the kind of behavior;

2. Invariant with the *actors* on the average among any sorts of people;
3. Permanent in *time* regardless of any historic period;
4. Universal in *space* transcending differences in regional cultures;
5. Important in *values* systems recording what men want most; and
6. Constant in residual *circumstances* which we usually attempt to describe for a first approximation in probabilistic terms.

It is because the shrinking-share hypothesis (which is as yet untested within this inverse power of a population model, P^{-q}) seems to us to be highly general in all six dimensions that we propose it in preference to alternative explanatory hypotheses until further controlled experiments will confirm whichever explanatory hypothesis best fits the facts.

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* All references are publications of S. C. Dodd, author of this article.

CONTACT PATTERNS IN THE CITY

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MANY writers have discussed and illuminated the character of the city-dweller's participation in the urban setting. One of the major areas of study has been that in which the changing ecological basis for friendship patterns has been examined. It has been pointed out by writers that friendship patterns are no longer restricted to within a neighborhood setting but that they tend to be based more on common membership in socio-economic strata, occupations or professions, work-groups, voluntary associations, and other such groupings.

Other writers have similarly indicated the increasing degree of geographical mobility characteristic of modern, urban populations. This paper reports a comparison of the distances travelled for the different purposes of visiting and shopping for an urban population. In this comparison the changing character of neighborhood participation will be demonstrated. Broadly, the purpose of the study was to examine the extent and quality of the city-dweller's participation in his urban environment.

This paper reports the results of 300 interviews with persons in the Los Angeles area. The distance travelled for various purposes by these persons will be examined below. The sample has been restricted to persons who managed the affairs of the home; that is, the interviewees were most often housewives or other persons who played an equivalent role in the home.

First, the average distances travelled by each of the interviewees were compared and analyzed by different characteristics of the interviewees. Secondly, the distances travelled and the number of contacts involved in visits with friends or rela-